Effect of Plant Growth Inducers on Morpho-physiological Traits of Corn (*Zea mays* L)

Ahmad Karimi[1], Reza Amirnia[2], Mehdi Tajbakhsh[3], Ali-Reza Eivazi[4], Korosh Karimi[5]

1. Young researchers Club, URMIA Branch, Islamic Azad University, URMIA, Iran
2. Associate Professor of Agriculture Department, Faculty of Agriculture - Urmia University
3. Full Professor of Agriculture Department, Faculty of Agriculture - Urmia University
4. Researcher in Agriculture and Natural Resources Research Center of Western Azerbaijan,Urmia-Iran
5. Young researchers Club, KHOY Branch, Islamic Azad University, KHOY, Iran

Ahmad_karimi@hotmail.com

Abstract: In order to study solvent-dispersing effect of inducing plant growth matters on morpho-physiological traits of double-cross 704 corn, an experiment was conducted under field conditions in complete randomized split blocks plan with 8 replications and 6 treatment of inducing plant growth matters: MARMARIN, HB_101, EXIN (INDOLE acetic acid), CYCOCEL, ETHEPHON, and control case. ANOVA results showed that the traits of stem diameter and height, length and number of panicle twigs, biological yield, and harvest index were significant at least in probability value of 5 percents. MARMARIN and HB_101treatments led to increase in stem length and diameter, biological yield and harvest index, and also, to reduction in number of panicle twigs. EXIN caused increase in stem length, length of panicle, biological yield and harvest index besides reduction of stem diameter and number of panicle twigs. Yet, level of yield increase was lower than the two previous treatments. CYCLOCEL and ETHEPHON resulted in enhancement of stem diameter as well as number of panicle twigs. ETHEPHON reduced biological yield as well as the stem length but did not exhibit a statistically significant difference for harvest index compared to the control treatment.

[Ahmad Karimi, Reza Amirnia, Mehdi Tajbakhsh, Ali-Reza Eivazi, Korosh Karimi. **Effect of Plant Growth Inducers on Morpho-physiological Traits of Corn (*Zea mays* L).** *Life Sci J* 2012;9(3):1683-1688]. (ISSN: 1097-8135). http://www.lifesciencesite.com. 245

Key Words: Cycocel, Marmarin, HB_101, Exin, Ethephon and Corn

Introduction:

Application of plant growth inducers in association with cereals growth treatment dates back to four decades ago [MOJTAHEDI & LESANI, 2005]. Role of growth regulators in global agriculture is low compared to other chemicals used in farming such as fungicides, pesticides and insecticides, and, global sales of plant growth regulators barely account for 4% of total turnover of different protective substances [PERAKASH & RACHAMANDRAN, 2000]. Application of regulating substances is occasionally intended to reach potential yield in crops and also to have the possibility of applying high planting densities as well as higher amounts of nitrogen fertilizers [PITULA et al, 1999]. Evident increase of energy cost, perpetual decline of fertile lands due to being transformed into urban and industrial areas, and the certain need to double food production in the world in near future all will guarantee exceeding role of growth regulators [MOJABI, 1994]. Change in plant height of corn results from variations of inter-nodal length not the number of internodes [KUCHEKI & SARMODNIA, 1998]. CYCOCEL application leads to development of shorter and thicker stems [MATOUS & MALDICUS, 1981] and also improvement of grain yield in wheat thanks to increased number of grains per unit area [SHEKUFA & EMAM, 2005]. Thickening of cellular wall and enhancement number of vascular successions are among the most significant anatomical effects of CYCOCEL on wheat [PITULA et al, 1999]. Future outline of corn cultivation is yield improvement in genotypes whose grain filling stage durations are long [KUCHEKI & BANAYAN, 1994]. ETHEPHON is a compound which remarkably influences plant growth through releasing ethylene and reduces longitudinal stem growth [Davis, 1988]. It is the simplest recognized OLPHIN with molecular weight of 28 Daltons weighing lighter than air under physiological conditions, [KAFI et al, 2000] and its application in wheat contributes to significant reduction of plant height and improvement of grain yield [Foster & FARIS, 1992]. EXIN is a term for plant growth substances that somehow stimulates the cellular lengthening. INDOLE acetic acid is the first extracted and identified growth inducing substance [KUCHEKI & BANAYAN, 1994]. MARMARIN is a natural growth inducer extracted from the seaweed SCHOPHYLUM NOSOSIUM and contains over 70 kinds of nutrients, enzymes, organic acids and plant growth inducers. Today, algae are widely exploited in industrial, agricultural, pharmacological and nutritional fields and modern technology is deployed for extraction and exploitation of algae in the advanced and industrial countries [SOHRABIPOUR et al, 2003]. Increase in growth inducers resulting from algae contributed to enhanced protein amount in pasture grasses and affected the amount of meat of livestock feeding on these pastures [Davis, 1981]. Weight of banana bunches increased 14 to 18 % by applying algae growth inducer and considerable enhancement was observed for corn as well [BLONDEN, 1972]. HB_101 is the trademark of a kind of growth inducer derived from decomposition and extraction of substances found in plants such as cedrus, pine, banana, plantago major and similar trees which feature long life and high stability; this inducer intensifies the mobility of substances in plants. Probably, the harmonic factors associated with dryness, light deficiency in dense plant areas or nitrogen deficiency cause growth stoppage and demise of ova fertilized in the tip [KUCHEKI & BANAYAN, 1994]. HB_101 consumption might be effective in yield improvement taking into account that nutrient absorption rate in corn declines after flowering [FAT-HI, 1999] and mobility of stem-accumulated matters –which comprise the excess products related to photosynthesis prior to grain filling stage- has a large contribution in grain yield [EVISTON et al, 1980; GALANGER et al. 1976]. Additionally, the amount of nutrients absorbed by a plant does not by itself determine total biomass or yield but consumption stage of nutrients is the determining factor, which unlike the absorption stage depends on internal properties of plant [EMAM & NIKNEZHAD, 1994]. Due to significance of corn production among cereals [fodders and grain], the yield might be directly or indirectly improved by impact of synthetic plant growth inducers and natural growth inducers. For this purpose, the current research analyzed the impacts of synthetic growth inducers (EXIN, CYCOCEL and ETHEPHON) and natural growth inducers made up of plants (MARMARIN and HB-101) together with control treatment on morpho-physiological traits and yield of corn.

Materials and Methods

In the current experiment, treatments included the grain corn (double-cross 704) affected by five growth inducers namely INDOLE acetic acid, CYCOCEL, HB_101, MARAMARIN and control case (no application of growth inducer).

Experiment Procedures: The experiment was carried out with 6 treatments and 8 replications using complete randomized split blocks plan in Agricultural Research Station, Uremia, Iran during the farming year 2008.

Farming Operation: The test field was initially in fallowed state. It was deeply ploughed by moldboard ploughs in early April 2008, and following surface rotavator, ridges and tillages were created in four corners of farm which was then split into plots. 48 plots were made, each 3*4 m2. After land preparation, insides the plots were superficially ploughed and then flattened by spade. The seeds were planted in the plots in four rows in 60-cm * 22-cm distances along each row and between two successive rows, respectively. The planting density and depth were respectively 75,000 plants per hectare and 5-7cm. To have reliable germination and complete number of plants in each plot, three seeds were planted in each hole; upon greening and alleviation of AGROTIS risk, two plants were eliminated from each hole and one plant remained intact. The fertilizers were consumed according to soil analysis results. 360 kg per hectare of urea compost was used in three stages (one third before planting, one third in 3-4 leaf stage, and one third in tasseling stage). Also, 100 kg of diammonium phosphate per hectare and 200 kilograms of sulfate potassium per hectare were uniformly applied in all treatments. Weeds were regularly eliminated during growth season, and to prevent dryness stress in plant, irrigation was regularly and meticulously implemented every 7-10 days throughout the vegetative period. According to experiment plan, treatment of inducers was applied as solution over the leaves twice: one week before and one week after the pollination. The traits under study were measured and recorded following application of treatments until harvesting the crops. Concentration of plant growth inducing and regulating substances were adjusted under farm conditions as below:

INDOLE acid a acetic: 20 ppm, CYCOCLE: 100 ppm, ETHEPHON: 33 ppm, MARMARIN: 1.5 liter per 1000 liters of water, and HB_101: 100 cc in 1000 liters of water (in accordance with instructions of manufacturing factory and their consumption levels in agricultural products and cereals). Variance analysis (ANOVA test) was performed on the obtained data using MSTAT_C software and the mean values were compared by means of LSD test in probability value of 5 percents.

Results and Discussions

Variance analysis (ANOVA) results implied that application of plant growth inducers affected the morpho-physiological traits in corn. The effect was significant at least in p-value of 5% on the following traits: stem diameter and height, number and length of panicle twigs, biological yield, and harvest index (Table 1).

Stem Length and Diameter

The traits of stem height and diameter exhibited very significant contrast under growth inducers treatment ($p<1\%$); the maximal increase of stem diameter and height respectively belonged to EXIN and MARMARIN treatments and the maximal reduction of stem length was observed in ETHEPHON treatment while EXIN had the lowest impact on stem diameter (Figures 1 and 2).

Table 1: Analysis of randomized complete blocks experiment under field conditions

		Mean of squares							
S.O.V	d.f	stem length	stem diameter	number of leaves per plant	number of leaves above the corn	length of panicle	number of panicle twigs	biological yield	harvest index
Replication (R)	7	91/94 ns	0/036 ns	0/432 ns	0/395 ns	1/457 ns	1/329 ns	66548/64 ns	25/482 ns
Treatment (T)	5	1995/933 **	1/047 **	0/84 ns	0/117 ns	6/534 *	89/659 **	3055790/471 **	474/277 **
Error	35	66/076	0/026	0/474	0/124	1/985	0/791	217062/918	12/885
Coefficient of Variations (%C.V)		3/18	7/73	5/94	6/32	3/1	8/06	11/4	13/9

ns, * and ** : Not significant, significant at ۵٪ and ۱٪ probability levels of probability, respectively.

INDOLE acid acetic led to increased longitudinal growth of stem cells and expansion of cellular wall [KAFI et al, 2000]. ETHEPHON has been used in a large group of plants and the results demonstrate that this substance reduces the longitudinal growth of stem [Davis, 1988]. ETHEPHON application in wheat resulted in significant reduction of plant height and improvement of grain yield [Foster & FARIS, 1992]. CYCOCEL administration leads to development of shorter and thicker stems through compaction of cellular cytoplasm and the height of the treated plant is reduced [MATOUS & MALDICUS, 1981]. Presence of harmonic compounds in algae composts contributes to enhanced growth and development of grass proteins in pastures up to 7 percents [SOHRABIPOUR et al, 2003]. Mobilization of stem-accumulated matters –which comprise the excess products related to photosynthesis prior to grain filling stage-, was to some extent helpful in improvement of grain yield. This phenomenon is further noticeable in grain filling stage particularly in the event of stresses such as dryness and high temperature [EVESTIN et al, 1980; GALANGER et al, 1976]. According to the analysis performed, corn plant height variations is not caused by changes in number of stem nodes but increase or decrease of stem length in cereals including corn is mainly due to change of inter-nodal size. And, variations of corn plant height also originate from changes of inter-node length not their number [KUCHEKI & SARMODNIA, 1998].

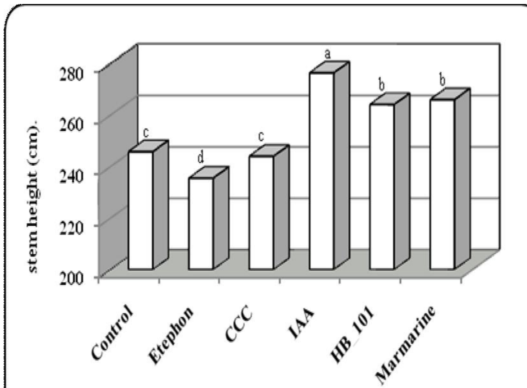

Fig 1: Effecte of Plant Growth Inducers on stem height.

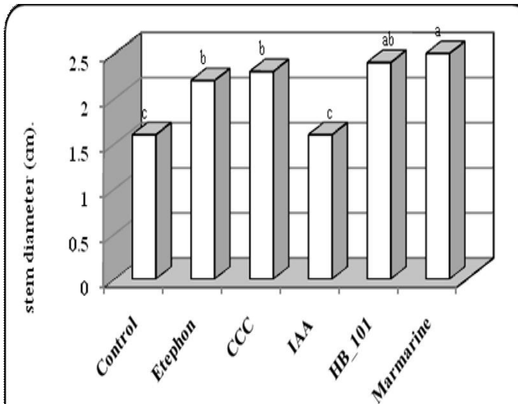

Fig. 2: Effecte of Plant Growth Inducers on stem diameter.

Number of leaves per plant and number of leaves above the corn

Number of leaves per plant and number of leaves above the corn did not show significant statistical difference in the tested treatments. This phenomenon can be attributed to fixed number of inter-nodes in corn plant.Number of leaves in each hybrid plant is generally linked to its growth season duration as delayed-growing hybrids assume larger leaf level compared to early-growing varieties [KUCHEKI & BANAIAN, 1994]. In the states where sucrose amount in leaves is high, vascular sheath cells have larger osmotic potential, and as such, facilitate the loading action due to mobilization of sugar towards the vascular sheath cells [KUCHEKI & SARMODNIA, 1994]. According to what discussed above, the growth inducers have probably affected the yield by indirectly influencing the upper layers of plant organs.

Panicle length and number of panicle twigs

Application of growth inducers revealed significant contrast on the traits of panicle length ($p<5\%$) and number of panicle twigs ($p<1\%$). Number of panicle twigs decreased significantly under treatments of MARMARIN, HB_101, and INDOLE acid acetic; the maximal decrease belonged to EXIN treatment. Panicle length significantly increased in INDOLE acid acetic treatment while all other treatments exhibited no significant difference compared to control treatment (Figures 3 and 4).

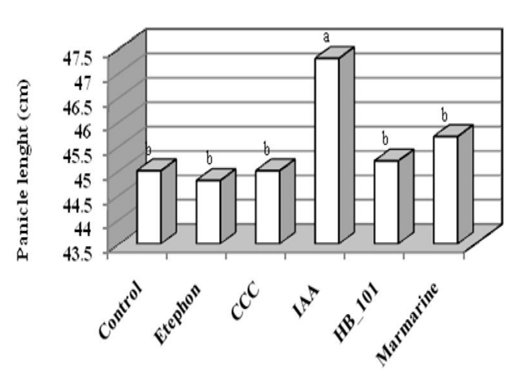

Fig 3: Effect of Plant Growth Inducers on Panicle lenght.

Small panicle in corn can be considered as a biogenic target because less shading will cover the terminal leaves which play substantial role in photosynthesis if number of twigs and length of panicle are reduced. Furthermore, the shortage of nodes can barely be assumed as responsible for infertility of ova and the reason is essentially due to delayed tasseling, which is in turn caused by deficiency of water, nitrogen and carbon hydrates [KUCHEKI & BANAIAN, 1994]. High yield might be expected through reduction of this trait in MARMARIN, HB_101, and to a smaller extent, EXIN treatments.

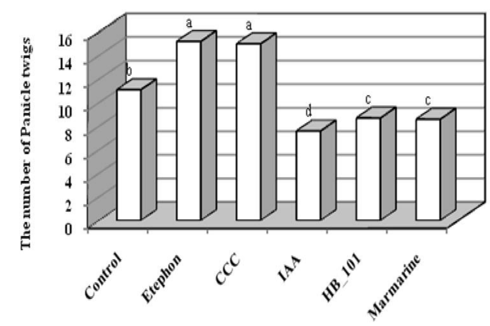

Fig 4: Effect of Plant Growth Inducers on the number of panicle twigs

Biological Yield

Biological yield of corn showed very significant statistical difference ($p<1\%$) in plant growth inducers treatments. The maximal enhancement belonged to MARMARIN treatment, and, ETHEPHON treatment caused a significant decline while CYCOCEL did not leave any significant effect on the biological yield (Figure 5). Grain and biological yields require appropriate equilibrium between the following agents: size of photosynthesis system and its consistency, photosynthesis rate, transfer (mobilization) and distribution of photosynthetic products to organs, number and size of grains and their capacity in terms of accumulation of photosynthetic products. And generally, supply of nutrients more than their absolute value determines the status of plant elements [KUCHEKI & BANAIAN, 1994].

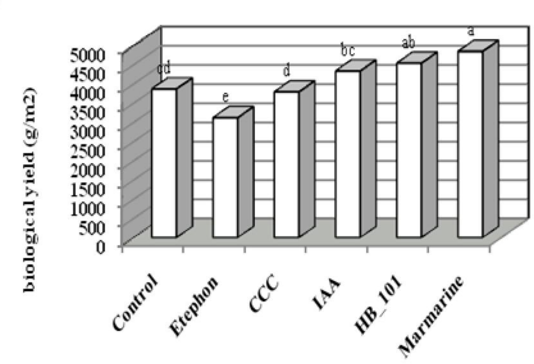

Fig 5: Effect of Plant Growth Inducers on biological yield.

Hormones affect distribution of photosynthetic products. Photosynthetic products are accumulated in hormone-contaminated areas when compounds such as INDOLE acid acetic, CYTOKENIN, ethylene and Gibberellic acid are applied on the cross-section of stem. Atriplex which is a pasture plant in Australia needs sodium as a low-consumption element. Apparently, sodium is required as a low-consumption element for the plants having 4-carbon photosynthesis systems, which probably relates to function of this element in ionic balance [KUCHEKI & SARMODNIA, 1998]. In addition, exceeded application of algae compost leads to increased protein content in pasture grasses and influences the meat amount in livestock feeding on these pastures [Davis, 1981].

Weight of banana bunches increased 14 to 18 % by applying algae growth stimuli and considerable enhancement was observed for corn as well [BLONDEN, 1972]. CYCOCEL application reduced the plant height and contributed to improvement of grain yield in wheat due to increased number of grains per unit area [SHEKUFA & EMAM, 2005]. ETHEPHON application together with different amounts of nitrogen fertilizer caused significant decrease in plant height and improvement of grain yield [Foster & FARIS, 1992]. Based on the former discussions, presence of sodium and calcium elements in HB_101 and MARMARIN treatments could be a reason for enhancement of biological yield.

Harvest Index

Treatment of growth inducers demonstrated significant statistical contrast on harvest index (p<1%). MARMARIN, HB_101, and INDOLE acetic acid improved this trait; the maximal increase belonged to MARMARIN and HB_101 treatments and no significant difference compared to control case was observed in other treatments (figure 6). Experiment results reveal the fact that mobilization of stem-accumulated matters, which comprise the excess products associated with photosynthesis prior to grain filling stage, was to some extent helpful in improvement of grain yield. This phenomenon is further noticeable in grain filling stage particularly in the event of stresses such as dryness and high temperature [EVESTIN et al, 1980; GALANGER et al, 1976]. Harvest index reflects ratio of photosynthetic products distribution between economical yield and biological yield [KUCHEKI & SARMODNIA, 1998]. Harvest index signifies ratio of grain yield to the biological yield, thus is less affected by the environment [FAT-HI, 1999]. Besides, 90% of increase in grain yield of fine-grained cereals mainly is due to improvement of harvest index [KUCHEKI & SARMODNIA, 1998]. Absorption rate of nutrients in corn declines after flowering [FAT-HI, 1999]. The amount of nutrients absorbed by plan does not solely constitute the total biomass or yield, but instead, the determining factor is nutrient consumption stage i.e. the stage in which the percentages of absorbed nutrients that form the yield are determined. This stage, unlike the absorption stage, directly depends on internal plant properties [EMMA & NIKNEZHAD, 1994].

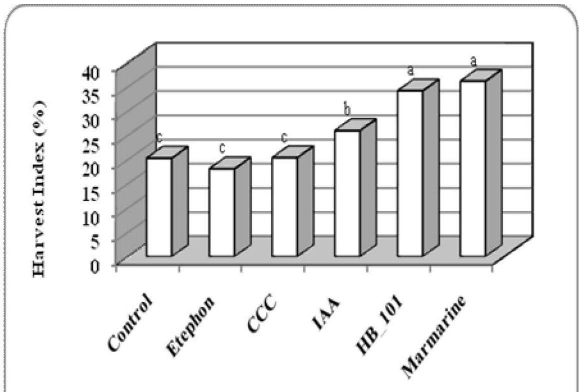

Fig6: Effect of Plant Growth Inducers on Harvest Index.

Application of plant growth inducers one week before and one week after pollination stage can contribute to improvement of biological yield and harvest index in corn. For example, MARMARIN treatment enhances biological yield of corn through increasing the leaf surface durability and photosynthesis duration and rate, lengthening duration of graining and grain filling periods without reducing length of vegetative period and by indirectly or directly influencing the improvement of mobilization rate of photosynthetic products from origin to destination. HB_101 achieves the same goal through increasing duration and rate of photosynthesis and nutrient absorption due to availability of different minerals and elements in its compositions, especially calcium and sodium ions, promoting production of sugars in plant, which in turn, leads to improvement of mobilization and loading rates and further and faster discharge of products between origin and destination. Harvest index is also probably improved through influence of these substances on grain yield and its components. INDOLE acid acetic also affects biological yield and somewhat improves the harvest index through helping the enhanced dominance of terminal germ, distributing the photosynthetic products, and promoting the absorption of substances near the treated areas. Failure of CYCOCEL and ETHEPHON to influence yield and harvest index, on contrary to a couple of formerly conducted researches, could result from different application stage and plant type (sort of cereal). Nevertheless, in addition to achieving goals of sustainable agriculture, improvement of vegetative yield and harvest index in corn by means of natural growth inducers such as MRMARIN and HB_101 (respectively derived and produced from algae and extract of plants) and also potential impact of these substances on yield of other cereals and even other pasture crops, could act as a preface for initiating new research works. However, extensive application of these compounds requires other researches to be carried out.

References

1. Austin, R. B; Morgan, C.L; Ford, M. A; and Blackwell, R.D. 1980. Contributions to grain yield from per- anthesis assimilation in tall and dwarf barleyphenotypes in two contrasting seasons. Annals of Botany.45: 309-319.

2. Blunden, G . 1972. Pruceding of 7 th Internasional Sea weed symposium. Japan. Pp.534-589.

3. Davies, P. J. 1988. The plant hormones: their nature, occureence, and functions. In:planthormones and their role in plant growth and development. Kluwer Academic Pub. Pp. 1-11.

4. Dawes, C. 1981. Mrine Botany. New York. Johan and Wiley and Sons. 628 Pp.

5. Fajeria. N. K. VEY; C. Baligar and Charles Allen Jones; 1999: Growth and Nutrition of Crops; Translated by GHODRATOLLAH FAT-HI; Mashhad JAHAD DANESHGAHI Publications; 372 Pp.

6. Foster, K. R; Reid, D. M; and Pharis, R. P. 1992. Ethylene biosynthesis and Ethephon metabolism and transport in barley. Crop Sci. 32: 1345–1352.

7. Gallagher, J.N; Biscoe, P.V; and Hunter, B. 1976. Effect of drought on grain growth. Nature 264:541-542.

8. Kafi. M; A. Zand; B. Kamkar; H. SHarafi and M. Gilani; 2000: Plant Physiology; Mashhad JAHAD DANESHGAHI Publications, 379 Pp. (Pages 201-205 and 299-310).

9. Kucheki. A. and GH.M. Sarmadnia; 1998: Physiology of Farming Plants; Mashhad JAHAD DANESHGAHI Publications; 400 Pp.

10. Kucheki. A. and M. BANNAIAN; 1994: Physiology of Agricultural Crops Yield (Translated); Mashhad JAHAD DANESHGAHI Publications; First Edition; 380 Pp.

11. Luis J. Nickel; 1994: Application of Plant Growth Regulators (Plant Hormones) in Agriculture, Translated by EBRAHIM MOJABI; Kermanshah RAZI University Publications; 166 Pp.

12. Mathews, P. R; and Caldicott, J. B. 1981. The effect of chlormequat chloride formulated with Choline Chloride on the height and yield of winter wheat. Ann. Appl. Biol. 97: 227-236.

13. M. Hee; Robert. K; and Androj Walker; 1994: An Introduction to Physiology of Agricultural Plants; Translated by YAHYA EMAM and MANSOUR NIK-NEZHAD; Shiraz University Publications; 572 Pp.

14. Mojtahedi. M and H. Lesani; 2005: Life of Green Plant; Tehran Publications; Pages 316-317 and 294-295.

15. Pietola, L; Tanni, R; and Elonen, P. 1999. Response of yield and N use of spring sown. crops to N fertilization with special reference.52Pp.

16.Prakash, M; and Ramachandran, K. 2000. Effects of moisture stress and antitranspirants on leaf chlorophyll, soluble protein and Photosynthetic rate in brinjal plants. J. Agron. Crop Sci. 184:153–156.

17. Sohrabipor. J; T. Nezhad-Sattari; M. Asasi; A. GHahraman; and R. Rabi'ei; 2003: A Research on Production of Brown Algae and Impact of Ecological Factors on These Species in BANDAR LENGEH's Beaches; Research and Construction; Number 59.

18. SHekufa. A. and Y. Emam; 2005: Effects of Different Nitrogen Levels and Growth Regulators (ETHEPHON and CYCOCEL) on Bread Wheat, Genotype Shiraz; Congress of Iran's Farming and Plant Biogenic Treatment Sciences; University of Tehran; ABUEIHAN PARDIS, 59 Pp.

07/30/2012